(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 March 2001 (08.03.2001)

PCT

(10) International Publication Number
WO 01/16493 A1

(51) International Patent Classification[7]: F04F 5/46

(21) International Application Number: PCT/CH99/00403

(22) International Filing Date: 31 August 1999 (31.08.1999)

(25) Filing Language: English

(26) Publication Language: English

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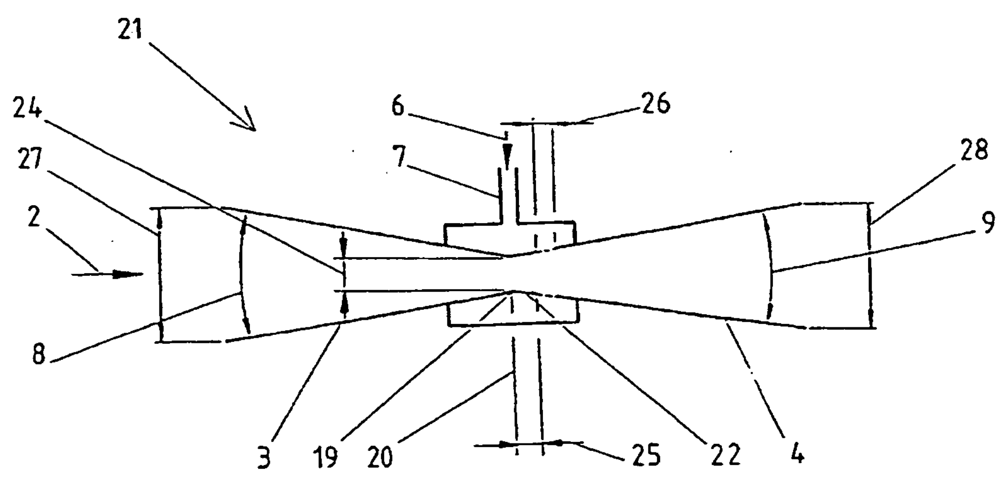
(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DOUBLE CONE FOR GENERATION OF A PRESSURE DIFFERENCE



(57) Abstract: The lifetime of a double-cone device (21) for creating a pressure difference in a streaming fluid can be greatly increased by moving the inlet gap (5) into the exit cone (4). This results in a short so-called diffuser (22) being obtained between the gap (5) and the orifice (19), where entry conc (3) and exit cone (4) are connected. The increased lifetime permits the double-cone device to cope with much higher flow rates. Thus higher system pressures are created which enhance the use of the double-cone for such applications as the desalination of sea water by reverse osmosis. The important application of the separation of oil from water using a separating device such as a cyclone (57) working under elevated pressure is now feasible. The increased power of the double-cone permits one to profit more fully from the new concept of reduction of the concentration of the feed supplied to the double-cone device (21).

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DOUBLE CONE FOR GENERATION OF A PRESSURE DIFFERENCE

Device for generating a pressure difference in a fluid and installations comprising it

The present invention relates to double-cone devices according to claim 1, particularly of the type disclosed in WO-A-87/01770. It further relates to installations comprising double-cone devices.

Double-cone devices are described in the WO-A-87/01770 whose content is incorporated in this description by reference. The double-cone device, amongst other things, allows one to upgrade the available pumping pressure of a modest conventional pump. When incorporated in a compressor loop, such as proposed in the aforementioned patent, numerous novel possibilities become evident.

The double-cone device essentially consists of two double-cones which are connected by their ends of small diameter. At the interface, i. e. interspersed between inlet cone and outlet cone, an orifice is provided. In the region of the orifice, the double-cone device, if penetrated by a fluid, builds up a surprisingly low pressure which allows another fluid to be drawn into the device with high efficiency. When included in a closed loop with a pump, the pressure in this loop can be increased in that the double-cone unit sucks in fluid until an equilibrium is attained. The term fluid refers to both liquids and gases.

The double-cone device is characterized by the angles θ_1 and θ_2 of the conicity of the inlet resp. the outlet cone:

$$F = (1 + \sin \theta_1)^2 * \sin^2 \theta_2$$

The quality function F should always be less than 0.11. The ranges are detailed hereinafter:

<0.0035:	best
0.0035 – 0.0155	very good
0.0155 – 0.0250	good
0.0250 – 0.0500	satisfying
0.0500 – 0.1100	still sufficient
> 0.1100	poor

In practice, however, the known double-cone devices showed a rather short lifetime.

Therefore, one object of the present invention consists in providing a double-cone device of increased lifetime.

Another object of the present invention is to provide new applications of the double-cone device, particularly the one fulfilling the first mentioned object.

A double-cone device complying with at least one of these objects is given in claim 1. The further claims indicate preferred embodiments and uses satisfying even the second object.

The invention will be described referring to Figures:

Fig. 1 Schematic illustration of a known double-cone device;

Fig. 2 Schematic illustration of a double-cone device according to the invention in a longitudinal section;

Fig. 3 Scheme of a known use of a double-cone device in a closed loop;

Fig. 4 Scheme of a first closed-loop system using a double-cone device;

Fig. 5 Scheme of a second closed-loop system using a double-cone device;

Fig. 6 Scheme of a third closed-loop system using a double-cone device;

Fig. 7 Scheme of a fourth closed-loop system using a double-cone device; and

Fig. 8 Scheme of a fifth closed-loop system using a double-cone device.

Before defining the source of the problems, it is necessary to describe the functioning of the double-cone device and the basic compressor loop. The original patented double-cone device and the basic compressor loop are presented in Figures 1 and 3, respectively. These schematics will be used to describe their mode of functioning.

Referring to Fig. 1, the double-cone device 1 is fed with a feed flow 2 that enters the entry cone 3 and discharges into the exit cone 4. As the feed flow crosses the gap 5, material 6 may be drawn into the inlet 7 and, consequently, into the exit cone 4. The inlet flow rate is dependent on a number of parameters including geometrical ones as well as the feed flow rate and the external pressures at the inlet and downstream of the exit cone.

The conicity θ_1 is the angle 8 between the walls of the entry cone 3, the conicity θ_2 is the angle 9 of the walls of the exit cone 4.

The basic compressor loop, which we will refer to as a double-cone technology (DCT) pump, is presented in Fig. 3. The pump 10 circulates liquid through the double-cone device 1 and round the main loop 12. Material enters the double-cone inlet 7 and causes a pressure rise within the main loop 12. This system pressure P is adjusted via the regulating valve 14 which controls the outlet flow 15 from the main loop 12.

The first problem stems from the geometry of the double-cone device 1. On progressively increasing the amount of material drawn into the device, a level is reached where the double-cone starts to destroy itself. The destruction takes the form of material torn out of the wall downstream of the entry to the exit cone. This damage renders the double-cone device inefficient and excessively noisy.

The basic double-cone device as presented in the WO-A-87/01770 is reproduced in Fig. 1. It is seen that the orifice 19 lies on the inlet plane 20. By moving this inlet plane 20 downstream of the orifice 19, as displayed in Fig. 2, and respecting the double-cone geometry, the wear problem is virtually eliminated. Experimentally, it appears that the inlet material 6 drawn into the double-cone device 21 is not subjected to such an extreme stress and so the wall material is better able to resist. In order to achieve the same suction pressure as the original double-cone device more feed flow rate is required. However, the short diffuser 22 attached to the entry cone 3 of Fig. 2 also results in a lower pressure-drop across the complete double-cone device 21. Thus, for a given pressure-drop more feed flow can be achieved with the modified double-cone device 21. The net result is that a similar suction performance to that of the known double-cone device 1 may be obtained without the

attendant cone damage. In fact, a lower pressure-drop is observed when comparing equivalent suctions.

Referring to Fig. 2, the orifice diameter 24 is represented by d and the small diffuser length 25 by L. The ratio of L to d is critical for the performance of the modified double-cone device 21. Values of L/d greater than 0.1 display improved life expectance and overall performance. As the ratio of L/d is increased, the overall pressure-drop across the modified double-cone device 21 decreases. In contrast, the maximum compressor pressure that can be achieved for a given feed flow rate decreases. The optimal trade-off occurs close to the value of L/d which yields just adequate compressor pressure for the available feed flow rate.

Other parameters for a particularly advantageous layout of the double-cone device are:

Ratio h/d of gap width h 26 to orifice diameter d 24: $0 < h/d < 3$, preferably $0.5 < h/d < 2$;

ratio D_{in}/d of entry diameter D_{in} 27 to orifice diameter d: $2 < D_{in}/d < \infty$, preferably $5 < D_{in}/d < 20$;

ratio D_{out}/d of entry diameter D_{out} to orifice diameter d: $2 < D_{out}/d < \infty$, preferably $5 < D_{out}/d < 20$;

conicity θ_1 8 of entry cone: $0 < \theta_1 < 10°$ (degree), preferably $\theta_1 < 8°$ and even more preferably $\theta_1 < 6°$; and

conicity θ_2 9 of exit cone: $\theta_2 \leq \theta_1$.

A direct comparison between the performances of the basic double-cone device 1 of Fig. 1 and the improved double-cone

device 21 of Fig. 2 may be derived from the following results:

Working conditions:

Feed flow rate	8 m^3 /h
Inlet flow rate	1 m^3 /h
System pressure P	35 bar

Observation:

Fig. 1 device:	Serious damage after only 20 minutes running time
Fig. 2 device:	No damage apparent after 40 hours running time

In addition to the increased lifetime, the operating noise can be reduced by this measure.

As a consequence of the significantly improved characteristics of the double-cone device according to the invention, industrial applications are conceivable where high throughput at high pressure and a reasonable lifetime is necessary or at least advantageous. One such application is the purification of water containing unwanted components, particularly the desalination of sea-water by reverse osmosis.

In a first approach according to Fig. 4, the reverse osmosis filter 30 may be directly inserted in the main loop 12. The purified fluid, e. g. desalinated sea-water, is recovered at the exit line 32 of the osmosis unit 30. Concentrated fluid leaves the main loop 12 via line 15 and valve 14. In this configuration, the solute concentration builds up progressively to a high stable level within the actual compressor loop. Consequently, the separation membranes 31 are required to reject a much higher solute concentration

than the one which existed originally in the untreated inlet supply. This results in an impaired solvent yield. Though, this layout of a purification system by reverse osmosis remains applicable, particularly under less demanding conditions, e. g. low concentrations of the matter to be separated.

The build-up of concentration within the compressor loop can be overcome by removing the separation membranes from the loop. This solution to the problem can introduce other difficulties because of the reduced membrane flushing. Typically, when functioning at high pressures, one may assume that only some 10 % of the main feed flow rate is available for supplying the separation membranes when placed external to the compressor loop. In Figures 5 and 6 of this patent application, a rearranged system is proposed that completely overcomes all these problems.

The schemes proposed in Figures 5 and 6 function according to the new principle of concentration reduction prior to entry into the DCT Pump. Referring to Fig. 5, the membrane of the entry osmosis unit 36 is supplied through line 37 on the higher pressure side of its membrane from the DCT pump downstream of the double-cone device 1. Liquid crosses the membrane and enters the supply stream 39, so the supply liquid in conduit 40 after the entry osmosis unit 36 is diluted. An optional feed pump 41 helps pressurise this stream at the inlet 7 to the double-cone 1. This additional pressure greatly enhances the performance of the DCT pump 10, both with respect to the system pressure and inlet flow capacity that can be achieved. The diluted supply stream leaves the DCT Pump on the high pressure side of the circulating pump 10 through conduit 43 and enters the exit osmosis unit 45. The system pressure is regulated by means of the two flow regulating valves 47 and 48 where the

concentrate leaves the installation. The purified liquid is collected at the solvent outlet 50.

For many low, medium and high pressure membranes that are currently available, pressure cannot be applied to the lower pressure side of the membrane for fear of rupturing the unit. Typically, less than 0.5 bar is specified for most spiral wound reverse osmosis and nanofilter units. Thus the optional pump 41 cannot be placed before the entry osmosis unit 36 in Fig. 5.

The advantage of this optional pump 46 is evident from the following results:

Hydraulic power of the optional pump relative to that of the circulating pump	9%
Net gain in relative hydraulic power at outlet from DCT Pump	50%

The logic behind the concentration reduction is that the incoming supply stream 39 is sufficiently concentrated to permit an exchange through a membrane by reverse osmosis between itself and a highly concentrated stream feeding the higher pressure side of the membrane. For example, 35 bar of pressure should counterbalance the inherent osmotic pressure across a semi-permeable membrane that is associated with an NaCl salt concentration gradient of at least 35 g/l (grams per litre). This compensation should be sufficient whether the membrane separates sea water from fresh water or sea water from a 70 g/l brine solution. In practise it has been observed, for a specific choice of membrane in the osmosis unit 36, that sea water reaches the DCT Pump with concentrations as low as 13 g/l.

The main difference between Figures 5 and 6 is that in Fig. 6, the conduit 52 which supplies the volume of liquid to the higher pressure side of the membrane in osmosis unit 36, branches off upstream of the pump 10 and upstream of the double-cone device 1 so that the volume of liquid supplied to the entry osmosis unit 36 does not have to pass through the **double-cone 1**. As a result, the circulating pump 10 for the Fig. 6 installation will use less power than in the Fig. 5 installation. However, for certain cases the highest pressure possible is required for each set of membranes, which could favour the choice of the Fig. 5 installation.

The installation shown in Fig. 7 specifically solves the problem associated with the membrane flushing requirement. The concentrate outlet of the exit osmosis unit 45 is connected to the entry osmosis unit 36 by the line 54. By so combining the concentrate lines from each block of membranes, the maximum volume of flushing liquid may be conserved. In addition, the membrane of osmosis unit 45 is able to function under more favourable conditions than those of the membrane of entry osmosis unit 36.

The separation of solids and/or dangerous contaminants from liquid carriers can present serious problems. If either reach the classic pumping device they can cause instant failure or provoke an explosion. Certainly, very expensive pumping equipment does exist for some explosive materials, but mostly one tries to side-track the problem.

For instance, the removal of crude oil from the sea has become a periodic nightmare in recent years. This contamination can be composed of light ends, which at best are highly inflammable, and heavy fractions which are of a tar-like consistency. In most instances this contamination can be traced to shipping leaks and often involves very

large quantities spread over huge surface areas of sea. The removal of this pollutant poses a major problem even with today's level of technology.

Most ports are contaminated with waste oil and detritus. This material is progressively polluting the coastal fishing and pleasure areas creating a toxic sea environment. Any proposed clean-up will involve the handling of hitherto unimagined volumes of water. With the double-cone modifications proposed in this patent application, a scheme such as that outlined in Fig. 8 should offer the necessary potential to make a serious contribution to this problem.

In Fig. 8, a separating device (a separating column, tower or cyclone) 57 is inserted directly into the main loop 12 downstream of the double-cone unit 1. With this arrangement the contaminated inlet material 6 is drawn into the double-cone 1 and flushed directly into the separating column 57. The least contaminated water returns to the main loop 12 from the lower portion of the separating device 57. Thus, the circulating pump 10 is virtually isolated from the contamination. Any solids that collect in the separating device 57 can be flushed from the base 59 of the separating device 57 via line 60 and valve 61, and the waste oil is recovered from the top 63 of the separating device 57 and guided through line 64 to outlet valve 65. The de-oiled sea water is ejected through valve 66. The efficiency of the separating device 57 depends to a large extent on the available pressure within the system. This is where the DCT pump will come into its own, because of its ability to upgrade the available working pressure of a very elementary high volume low pressure rugged pump as circulating pump 10.

The invention has been described by means of illustrative examples. However, the scope of protection relating to this

invention is not restricted to the examples set forth but determined by the claims. It is clear that one skilled in the art will be able to see numerous variants derived from the basic concept. Some such modifications are presented below.

- The addition of a second variable gap, whose entry plane coincides with the orifice, introduces the possibility of temporarily increasing the available suction.
- The exit cone downstream of the gap 5 can be sectioned so as to include several secondary gaps. In preference, each of these gaps is equipped with the possibility of partial or total closure. The secondary gaps can be chosen with various heights and/or distances from the orifice.
  The variable gaps, covering the range of fully open to closed, can be realised as follows:
  - A section can be removed from the exit cone and a shutter ring used to vary or completely close the gap.
  - A cut made through the exit cone and one part moved relative to the other.
  - One or several holes can be introduced in the wall of the exit cone with the possiblity of varying the opening by means of either a shutter, shutter rings or valves.
- The double cone modifications proposed above can be introduced into the applications and installations depicted in the main text.
- The installations for implementing the new application can comprise more than one double-cone device, separating unit or pump. In particular, the double-cones can be arranged in parallel or in series. The parallel arrangements sometimes require individual flow controlling devices for each branch.

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Claims

1. Double-cone device (21) for creating a pressure difference in a fluid penetrating the device, the device essentially consisting of an inlet unit (3) and an outlet unit (4), each of essentially hollow frustroconical shape, and the entry unit (3) and the exit unit (4) being connected by their respective first ends of small diameter creating an orifice (19), characterized in that at least one first inlet opening (5) is provided in the outlet unit in a distance from its first end, so that between the inlet (5) and the first end of the exit unit a section (22) of increasing cross-cut and an effective length L exists in order to decrease noise and/or wear of the double-cone device.

2. A double-cone device (21) according to claim 1, characterized in that at least one of the first inlet openings is one of the following:

- a hole, preferably of essentially circular crosscut;
- a sequence of openings in the exit unit wall on the circumference of a circle in a plane essentially transversely to the exit unit; or
- a circular gap (5) in the exit unit, preferably essentially transversely to the exit unit (4).

3. A double-cone device according to one of claims 1 to 2, characterized in that at least one, preferably all, of the following parameters are obeyed:

ratio h/d of gap width h (26) to orifice diameter d (24): $0 < h/d < 3$, preferably $0.5 < h/d < 2$;

ratio D_{in}/d of entry diameter D_{in} (27) of entry unit (3) to orifice (19) diameter d: $2 < D_{in}/d < \infty$, preferably $5 < D_{in}/d < 20$;

ratio D_{out}/d of entry diameter D_{out} of entry unit (3) to orifice (19) diameter d: $2 < D_{out}/d < \infty$, preferably

$5 < D_{out}/d < 20$;

conicity θ_1 (8) of entry unit (3): $0 < \theta_1 < 10°$ (degree), preferably $\theta_1 < 8°$ and even more preferably $\theta_1 < 6°$; and

conicity θ_2 (9) of exit unit (4): $\theta_2 \le \theta_1$;

and that the quality function $F = (1 + \sin\theta_1)^2 * \sin^2\theta_2$ is at most 0.1100, preferably smaller than 0.05, more preferably smaller than 0.0250, even more preferably smaller than 0.0155 and most preferably smaller than 0.0035.

4. A double-cone device according to one of claims 1 to 3, characterized in that the ratio of the length L to the width d of the orifice (19) is at least 0.1.

5. A double-cone device according to one of claims 1 to 4, characterized in that the parts of the exit cone (4) delimiting at least one gap (5) are movable with respect to each other in order to adjust the gap's width h.

6. A double-cone device according to one of claims 1 to 5~~6~~, characterized in that at least one gap consisting of a series of openings is covered by a conical ring with openings corresponding to those of the gap, the ring being further rotatable attached to the exit unit (4) so that by rotating the conical ring, the openings of the gap can be opened or closed in a continous manner.

7. Installation of a double-cone device (1; 21), preferably according to one of claims 1 to 6, for creating a pressure difference in a fluid penetrating the device, the device essentially consisting of an inlet unit (3) and an outlet unit (4), each of essentially hollow frustroconical shape, and the entry unit (3) and the exit unit (4) being connected by their respective first ends of small diameter creating an orifice (19), characterized in that the double-cone device (1; 21) is arranged in a closed loop (12)

comprising at least a pump (10), one or more outlets (14, 15; 37, 43) and a separating unit (30; 36, 45) which when fluid is guided through it, is capable of separating components from the fluid, and which necessitates overpressure for its function or shows improved performance with increasedly pressurizing the supply fluid, the separating unit being either inserted into the closed loop (12) or connected to at least one outlet.

8. Installation comprising a double-cone device (1; 21) according to claim 7, characterized in that at least one of the separating units is a first separation unit (36) allows mass exchange between two fluids, particularly an osmosis unit (36), the separating unit being connected to an outlet (14, 15; 37, 43) and the inlet (7) of the double-cone device (1; 21), so that a mass-exchange between the fluid exiting the closed loop (12) end the fluid entering the loop (12) through the separating device (36) and the inlet of the double-cone device occurs so that the concentration of matter to be separated from the fluid is reduced in the entering fluid.

9. Installation according to one of claims 7 to 8, characterized in that at least one of the separating units is a second separation unit (45) connected to an outlet (14, 15; 37, 43), the second separation unit being capable of separating matter from the fluid, particularly by osmosis, reverse osmosis, filtration, cyclone effect, or chromatography, in order to recover purified fluid and/or concentrated fluid at the exit of the second separation unit.

10. Installation according to one of claims 7 to 9, characterized in that at least one of the separating units is a third separation unit (57) for separating matter from a

fluid and is inserted in the loop (12) so that the fluid circulating in the loop passes through the third separating unit (57), the third separating unit being preferable one of the following: an osmosis unit, a reverse osmosis unit, a cyclone, a separating column or tower.

11. Installation according to claim 10, characterized in that the third separation unit (57) is arranged upstream of the pump (10) and is suited to remove corrosive, abrasive and/or aggressive matter from the circulating fluid in order to protect the pump.

12. Installation according to one of claims 7 to 11, characterized in that a pump (40) is connected with the inlet (7) of the double-cone device in order to improve the supply of fluid to the double-cone device.

13. Use of the installation according to one of claims 7 to 12 for the desalination of sea-water, separation of contaminations like oil from water.

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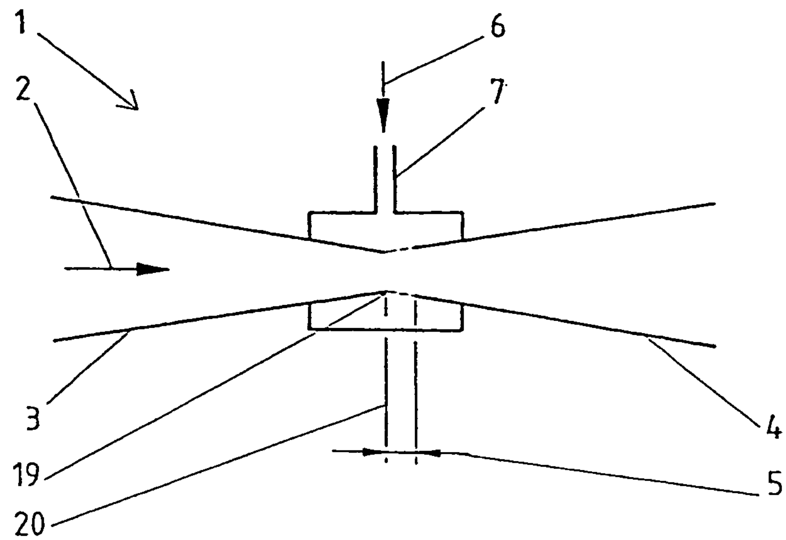


Fig.1

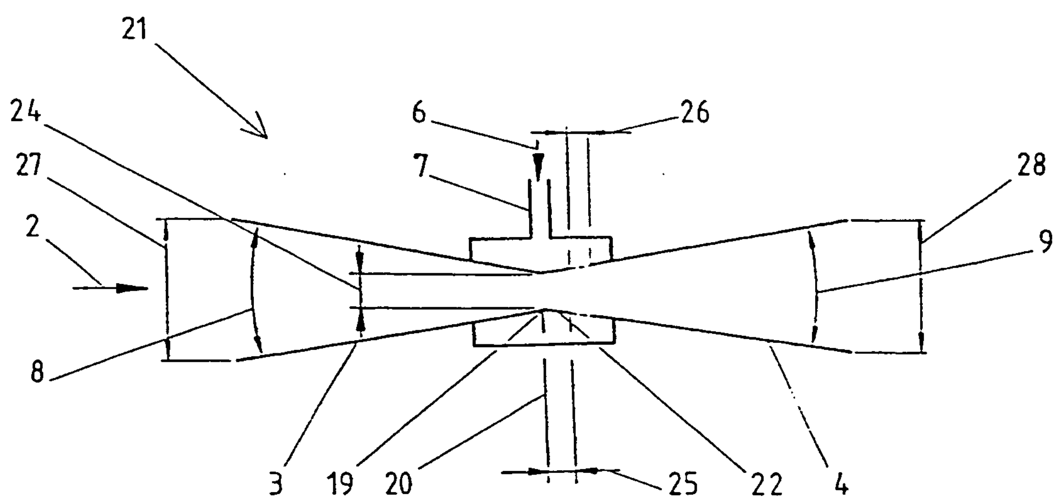
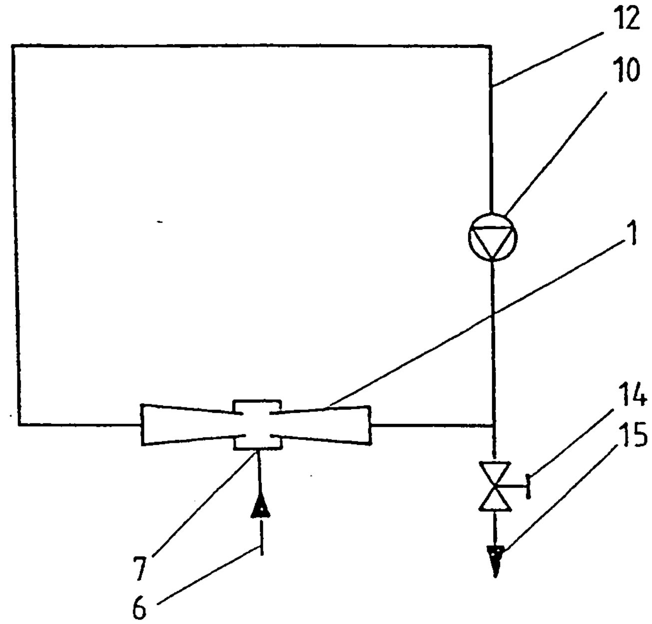


Fig. 2

Fig. 3



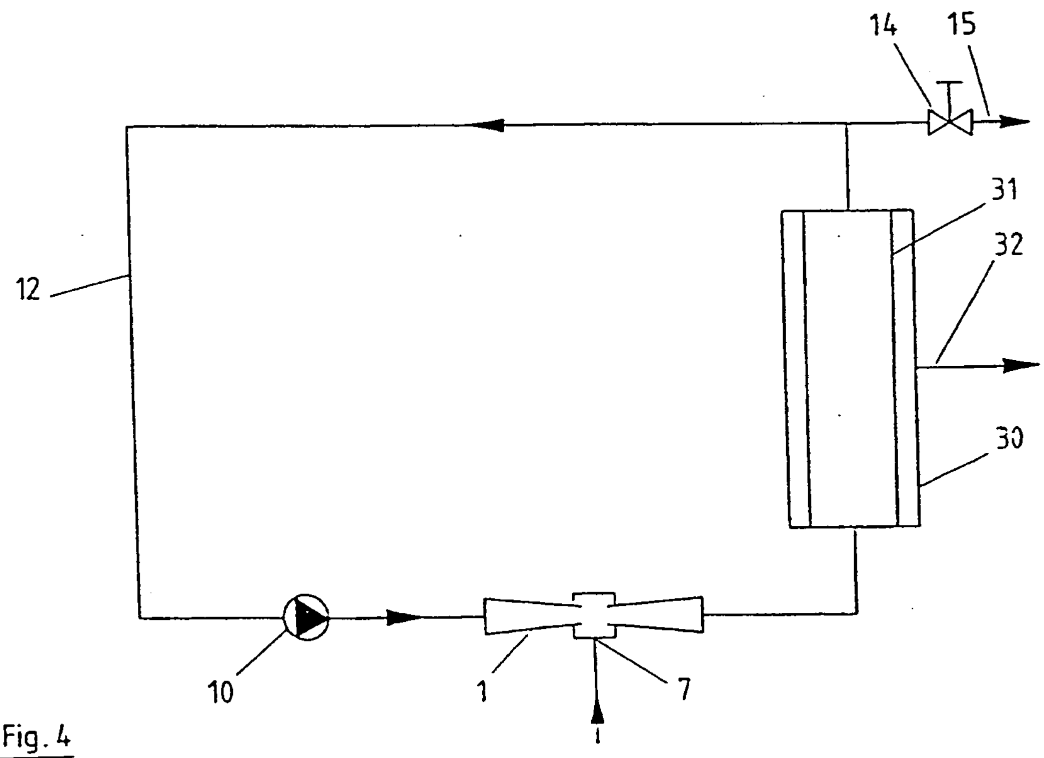


Fig. 4

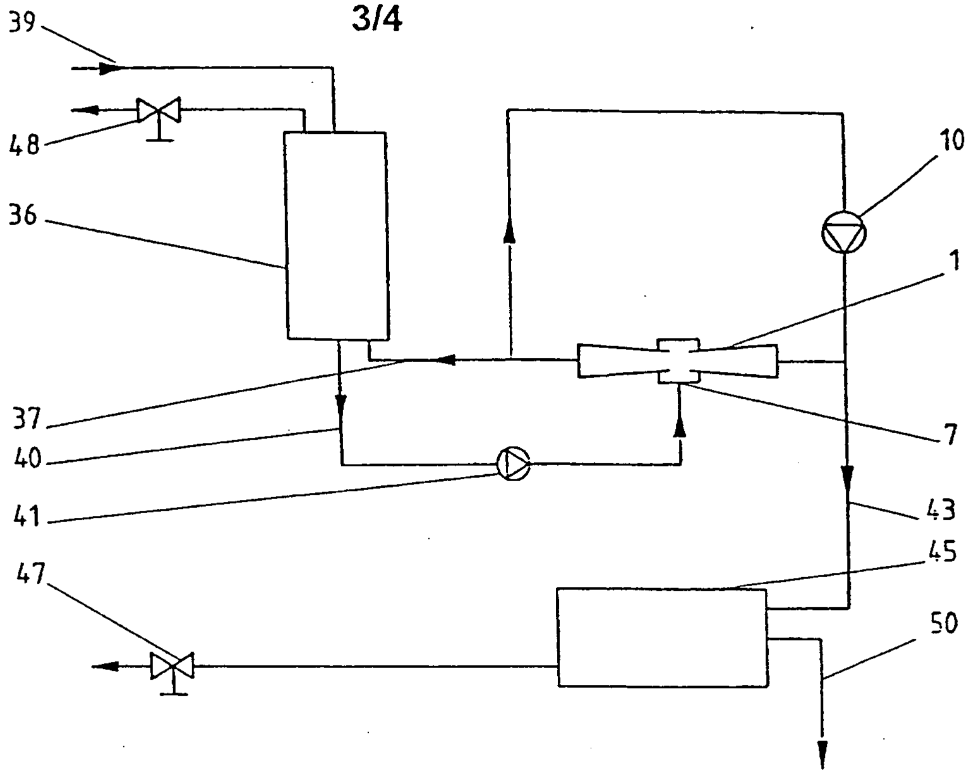

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Fig. 5

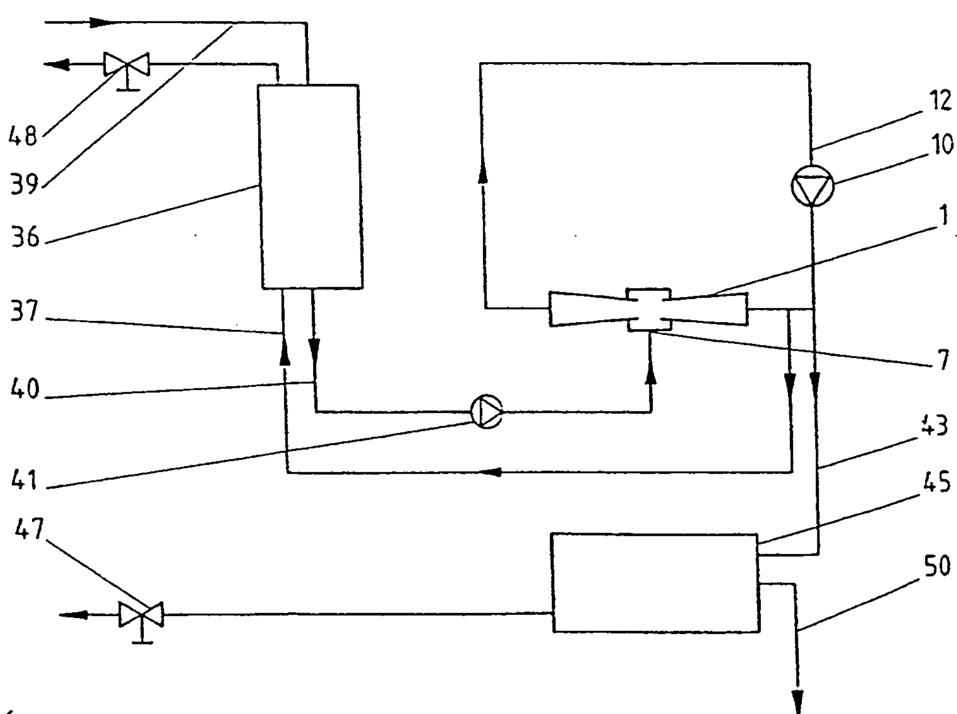
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Fig. 6

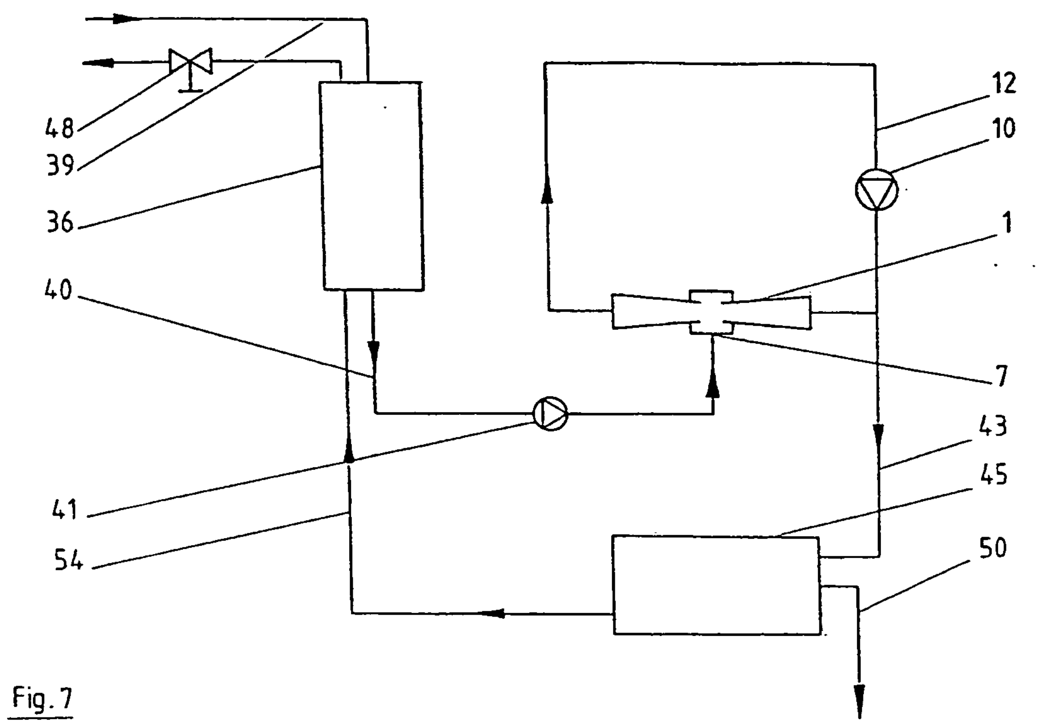
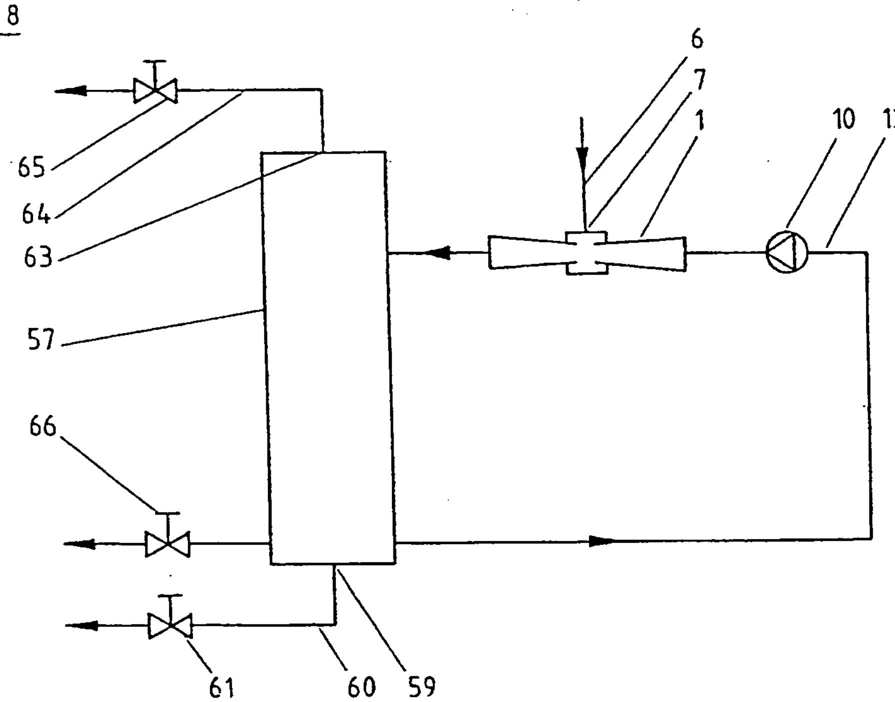


Fig. 7

Fig. 8



INTERNATIONAL SEARCH REPORT

Intern :al Application No
PCT/CH 99/00403

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F04F5/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F04F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	NL 6 811 379 A (A.S.W. APPARATENFABRIEK N.V.) 11 February 1970 (1970-02-11) page 2, line 11 -page 3, line 8	1 2-4
X	FR 2 580 191 A (BAYEN JEAN) 17 October 1986 (1986-10-17) page 8, line 23 - line 31 page 11, line 4 -page 12, line 35; figure 1	1
X	NL 6 555 C (HIGGINS, C. F.) the whole document	1
X	US 4 625 744 A (ARNAUDEAU MARCEL) 2 December 1986 (1986-12-02) the whole document	7-10

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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17 July 2000	25.07.00

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European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Jungfer, J

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 190 537 A (BRAY DONALD T ET AL) 26 February 1980 (1980-02-26) column 3, line 1 -column 6, line 50 ---	7-9
Y	HOGGARTH, M. L.: "The design and performance of high-pressure injectors as gas jet boosters" PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS, vol. 185, no. 56/71, 1970 - 1971, pages 755-765, XP002136257 the whole document ---	1-3
Y	EP 0 612 078 A (CISE SPA ;ENEL SPA (IT)) 24 August 1994 (1994-08-24) page 2, line 44 -page 3, line 40 ---	1-3
A	FR 740 179 A (GERIN, MARTIAL) 21 January 1933 (1933-01-21) the whole document ---	1
A	US 4 027 407 A (KISS SANDOR G) 7 June 1977 (1977-06-07) column 2, line 57 -column 3, line 9 column 3, line 34 - line 41 figures 2-5 ---	1
A	WO 87 01770 A (STRAUB PAUL WERNER) 26 March 1987 (1987-03-26) cited in the application page 1, line 28 -page 9, line 24 figures 1-5,14 ---	1-4
A	FR 2 239 142 A (UTILISATION RATION GAZ) 21 February 1975 (1975-02-21) page 5; figures 1-4 ---	1-3
A	DE 972 270 C (ZIMMERMANN, L.) 18 June 1959 (1959-06-18) the whole document ---	1-4
A	WO 98 58175 A (PETROUKHINE EVGUENI DMITRIEVIC ;POPOV SERGEY ANATOLIEVICH (HU); DO) 23 December 1998 (1998-12-23) abstract ---	7-13
A	WO 98 58176 A (PETROUKHINE EVGUENI DMITRIEVIC ;POPOV SERGEY ANATOLIEVICH (HU); DO) 23 December 1998 (1998-12-23) abstract ---	7-13
A	WO 99 08003 A (POPOV SERGEY ANATOLIEVICH ;DUBINSKI ANATOLI MOISSEEVITCH (RU); PET) 18 February 1999 (1999-02-18) abstract --- -/--	7-13

4

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 599 281 A (WAT WASSER UND UMWELTTECHNIK G) 1 June 1994 (1994-06-01) page 1, line 24 - line 31 page 7, line 37	7-13
E	CH 689 722 A (STRAUB PAUL WERNER PROF DR MED) 15 September 1999 (1999-09-15) the whole document	1,7-13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CH 99/00403

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

As a result of the prior review under R. 40.2(e) PCT, part of the additional fees are to be refunded.

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☒ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

   1-4,7-13

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☒ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-4

   Reduction of wear or noise of the nozzle by choosing the ratio length L to width d to be at least 0,1.

2. Claims: 1,5

   Adjustment of flow pattern such as boundary layer characteristics

3. Claims: 1,6

   Increase of suction pressure by use of a rotary valve-like structure

4. Claims: 1,7-13

   Separating unit for separation of components from the fluid

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CH 99/00403

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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